Design Science Research for Holistic Climate Services

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Abstract. The innovated fitness-utility Systems Design Research (SDR) model is generalized from the Extended Action Design Research (EADR) model and discussed in terms of the Design Science Research (DSR) framework. In the context of SDR as well as the recent Paris Agreement, the 2030 Agenda for Sustainable Development and the Agenda for Humanity the challenges of holistic climate services are discussed. As an application of the trans-disciplinary SDR holistic grass-root mobile climate services are developed for local farmers in communities of an African developing country.

Keywords: Design science research · Fitness-utility model · Trans-disciplinary systems · Holistic climate services

1 Introduction

In the discussed research in progress we are concerned with obvious demands for designing holistic grass-root mobile climate services (HGMCSs) to empower local farmers in communities of an African developing country to cope with the changing climate. The services are critical because traditional tacit knowledge no more works. The task includes increased awareness of climate impacts and the improvement of our trans-disciplinary baselines to meet them. In concert with the recent Paris Agreement (PA) [1], Transforming our world: the 2030 Agenda for Sustainable Development (ASD) [2], Agenda for Humanity (AH) [3] and Natural Disasters and Climate Change: Managing Risks & Crises Differently (NDCC) [4] our effort is to get a holistic view included in climate services and our prototype HGMCSs landed for active use and further participatory development by local farmers. The subjective demand, not only the objective need for HGMCSs became apparent during our several pilot studies since 2011 in different grass-roots level contexts in Africa.

The four references [1-4] mentioned above give an overall view of the current situation of the global leadership in climate change issues. Formerly UN Framework Convention on Climate Change (UNFCCC) with its Conferences of Parties (COPs) kept the leading role in climate change issues by global agreements on climate change, like the Kyoto Protocol of 1997 and PA.

Recently the UN General Assembly has released as its resolution the ASD. This agenda includes nineteen Goals of Sustainable Development with Goal 13 “Take urgent action to combat climate change and its impacts”. ASD presents the social, economic, and environmental dimensions as the three dimensions of the sustainable development.

ASD integrates them, climate included, fully in a coherent, holistic, comprehensive and balanced way.

The Secretary-General of UN released AH in the World Humanitarian Summit (WHS) in 2016 in Istanbul. In addition WHS released also NDCC, in which the Core Commitment 1 repeated the urgency of ASD Goal 13.

As a consequence of the actions mentioned above UN has taken the global leadership in integrating the issues of climate change and its impacts into ASD and AH.

Regarding the climate change and its impacts PA gives to us recommendations how we can contribute to limit and to stop the human-induced climate change to a bearable extent. In changes of climate impacts we focus on two changes in climate, on changes in extreme values and on changes in climate variability. These are the aspects, which impact most directly the baselines of the societies.

One crucial question to accomplish sustainable development is to achieve a climate with stable mean values and stable variability. For design science SDR with its artifacts offers one possibility to contribute to the development of sustainable holistic climate services.

As the needed Design Science Research (DSR) [5] tool we present and discuss the setup, the stages and the objectives of the Systems Design Research (SDR) fitness-utility model, which is a generalization of the Extended Action Design Research (EADR) model by Mullarkey and Hevner [6]. In the same context, we introduce the Epistemic Implementation Delphi (EID) model with its stages as the design artifact of SDR. Finally, we outline some prospects of SDR and conclude our presentation.

2 Systems Design Research

We develop SDR to study several concurrently interacting systems. In fig. 1 we present the stages of our Systems Design Research (SDR) fitness-utility model on the continuum of the entry point chain of our trans-disciplinary Epistemic Implementation Delphi (EID) model.

The stages of SDR resemble the stages of EADR. However, in the first left-hand box we have replaced motivation by encountering, which in the case of developing countries means that the primary idea of the project should come up from the local grassroot discussions and preferably from local farmers. More generally the primary idea of the project should be presented by the end-users. The inclusion of end-users as experts of their own condition is complementary if not contradictory to conventional development projects where the motivation to set up a project is based on needs that are usually explicated by external experts.

Concurrently during the encountering, we search competent members to SDR completion team primarily from the local community and from local pertinent expert institutes. The role of outside supervisor parties, like representatives of foreign development aid should be relatively strong at the beginning of the project and decrease during the participatory working phase.

It is important to recognize that the epistemic base of EID is the General Theory of Consistency (GTC) [7]. According to GTC the local population participating to the

project experiment on grass-root level is divided into two groups: not-learning beings, who trust on the use of traditional tacit knowledge, and learning beings, who are willing to learn and use advised modern methods.

In the second box from the left the chosen EID expert team looks for possible rational artifacts during the opening stage and leaves them all available for the process. In case of considerable uncertainties, like in the development of HGMCSs, EID expert team together with SDR completion team determines the criteria of a sufficient solution in terms of both utility and fitness.

At the design and development stage of SDR the expert team of EID elaborates further the action lines as rational artifacts. This takes place at the opening and especially the argumentation stage of EID. It is important that the elaborated artifacts as different versions of the developed climate services are kept separate from each other. The outcome of the design and development stage of SDR is one artifact recommended by EID expert team to be implemented in the demonstration stage by EID management team.

The completion team of SDR together with the expert and management teams of EID evaluates the implemented artifact to check, whether this artifact meets the utility and fitness criteria of sufficiency. If so, then the concluding stage of EID is accomplished and SDR proceeds to the communication stage. In case the outcome of the implemented artifact is not sufficient, the completion team of SDR returns the process back to the design and development stage to pick up the artifact option next on the recommendation list for implementation. This iteration is executed in as many loops as needed to find a sufficient outcome or all available artifacts being scrutinized. Thereafter SDR completes the communication stage with appropriate scholarly and professional publications.

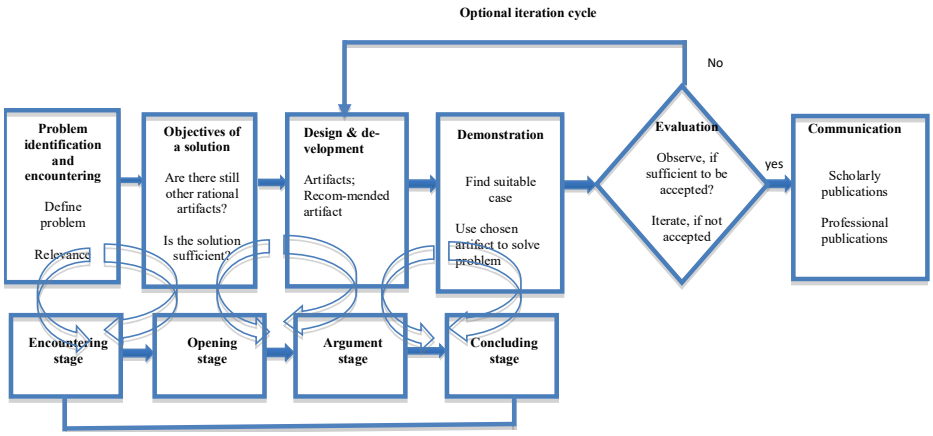

Fig. 1. Allocating the stages of SDR on the research entry point chain of EID (adapted from [6]).

3 Design Science Research

Next, we discuss SDR in terms of DSR framework [5] depicted in fig. 2. Where appropriate we focus our discussion on our particular application of SDR in the development of HGMCSs for local farmers in communities of an African developing country.

Environment. We start with the environment and in it with people. In our coming prototype project, we have three groups of people: the local farmers of the communities (LCG), the various kinds of local experts extending from the community to the national level (LNG), and the supervisors from the foreign development aid party (SFG).

Ideally the first encountering should take place by a meeting of LNG and SFG, when a letter of intent has been sent or preliminary discussions of intention on a joint SDR project have taken place. The expertise of LNG should include scientific experts on relevant invariances and experts on local social aspects and human behavior, decision makers with the authority to allocate needed local resources as well as funding, and synthesizers with the overall vision to become supervisors. Compared with LNG, the composition of SFG should rather be experts on decision-making issues and have the needed backup in funding issues. The outcome of this meeting should be a draft of the project agreement, the mutual written understanding of the joint objectives and commitments, and the written consent of the right to archive and use the compiled video-recorded interviews as well as other collected data.

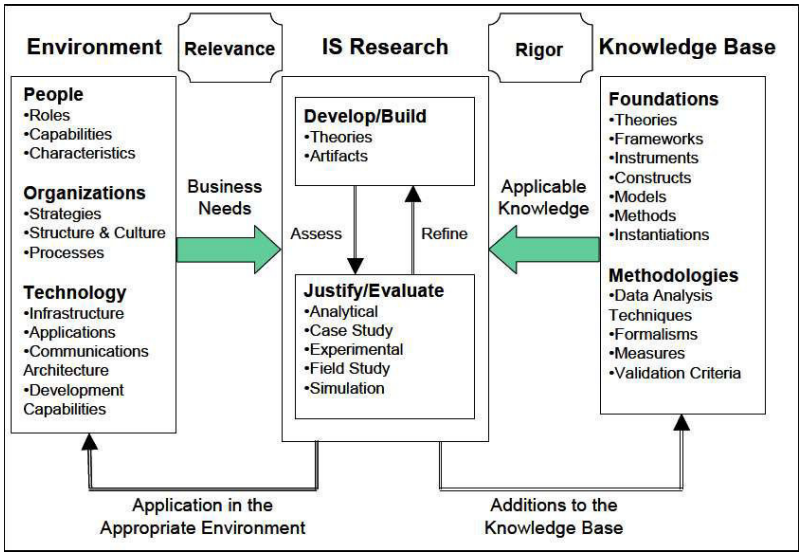

Fig. 2. Design Science Research Framework [5].

Early prior to the expected rain season LCG not-learning and learning groups of the participating communities should together make overall crop cultivation plans, where every community decides the cultivated crop species, the tilling method, and the possibly used fertilizer, pesticide or plant disease control agent. During this planning, the

local farmers consult the needed national expert institutes, like the national institute of agricultural research as well as the national meteorological and hydrological institute, in order to get advice on proper crop selection, expected precipitation, risk for draughts, floods, pests, and plant diseases for the coming rain season. Co-designing the services need to be closely tied to the planning activities.

After the overall cultivation plans are ready the local decision-makers plan the allocation of the needed separate experiment parcels for the not-learning and the learning farmers on a fair basis including also the access to eventual irrigation. The crop yields of the parcels are compared under the assumption that both groups have equal access to the information disseminated by HGMCSs. As our approach is holistic we cannot limit our scope just to develop technically appropriate trans-disciplinary climate services and compare their effects. In developing countries, we have several other factors affecting significantly the crop yield, like the use of quality seeds, fertilizers, pesticides, plant disease control agents as well as of modern tilling methods. The local experts need to consider, which of these factors need to be included explicitly in our field experiments in the form of additional parcels so that we can convincingly demonstrate the sufficient success of the developed HGMCSs.

All human-driven activities presented above tie the people, pertinent organizations and technologies to joint business needs, which are elaborated further under the develop/build and justify/evaluate phases of the trans-disciplinary DSR. The objective of these efforts is to develop beneficial local HGMCSs and to take place under SDR steered EID actions.

Knowledge Base. We introduced SDR combined with EID as a fitness-utility model [8]. It is our contribution to the knowledge base.

Regarding the fitness of our model we assess it in terms of the fitness definition #2 [8]. With HGMCSs and holistic views in mind we need to take into account pertinent aspects of human and social behavior. Here an essential part of the collected data consists of compiled and video-recorded interviews, including especially those from the co-design process. As guidance for the interviews we use the set of twelve questions of the Critical Systems Heuristics (CSH) [9], which in our application concern boundary judgments of particular HGMCSs. The consideration of boundary judgments and the possible extension of the boundaries of our design space stand both for an opportunity and a necessity in the development of HGMCSs. All in all, this makes our fitness considerations an exciting and demanding challenge where experience and resilience are needed.

In the context of our design artifact EID the utility has to cover two aspects, the metric utility for measurable quantities, like crop yield, and the epistemic utility for assessed qualities, like motivation. To build the metric utility function is a straightforward objective matter, whereas the epistemic utility is a different issue and involves subjective evaluations. As a first trial, we form an epistemic utility function by dichotomizing the observations on a one step scale from zero to five as follows: 0 = cannot be assessed, 1= very poor, 2 = moderately poor, 3 = medium, 4 = moderately good, and 5 = very good. One more sophisticated way to assess the epistemic utility would process the original transcribed video-recorded interviews by applying the Computer Aided

Qualitative Data Analysis Service (CAQDAS) [10] with the Transana qualitative analysis software for text, audio and video data [11] to help us to explore the design space and to find new aspects in it.

The nine first questions of CSH apply to those, who use and develop HGMCSs and are involved in the process. The first three questions are on motivation, the next three on control and questions seven to nine on knowledge. The last three questions concern those affected by the process, like neighboring communities, and are on legitimacy. The interviewer presents the questions both in the form "ought to be" and "is/are", the former pointing to the future and the latter to the presence. According to Ulrich and Reynolds [9] it is easier to start the interview with the "ought to be" questions, which allow the interviewee to respond by future wishes. Thereafter the "is/are" questions on the present situation become easier for the interviewee to answer. For newcomer CSH interviewers Ulrich and Reynolds [9] have recommended an order to present the questions. However, the questions are independent and can be presented in the order an experienced interviewer finds appropriate for a particular interview. As Ulrich [12] pointed out the quest for competence in CSH is a life-long learning process.

With the observed changes of climate and climate variability we recognized that our representative climate records were short. Therefore, our current climate records include considerable uncertainties in the epistemic meaning of the word. Then reliable risk estimates by statistical methods are not possible to make. In addition, in developing countries data records of other pertinent disciplines, like agriculture, are at their best sporadic and inhomogeneous. All in all, classical statistical methods cannot be applied. In concert with this we include CSH into our fitness-utility model. In addition, we will take into account advances in heuristics [13].

IS Research and the Design Cycle. With reference to the first framework Systems Design Research we discuss here only the box on justify/evaluate.

After having accomplished and submitted our article on the theory and artifacts of SDR, EID and CSH we implement a field experiment in some representative communities of an African developing country in Ethiopia or in Kenya as a prototype case study of our fitness-utility model. We start this by building our preliminary plan for the first encountering meeting, which we hope to take in the African host country in summer 2017.

At the first encountering meeting, we need to establish the core network of the joint project and ascertain our mutual engagement to it. In addition, the needed prior capacity building of local focal persons and students as well as practical arrangements for the whole period of the project need to be discussed, agreed and delegated in a truly participatory manner. Already from the beginning we need a convincing local commitment to the project and the development of HGMCSs so that by the end of the project its ownership is in active and firm local hands for further development. This means also that we have to ensure that our joint undertaking has the local funding for the needed operative expenses and sustainable development. We, the representatives of the foreign development aid funding, make clear our role as kicking off the development of HGMCSs to support local sustainable development in terms of improved crop cultivation and food security.

One crucial issue throughout our project is communication. Not to underestimate the role of the publications smooth, open and pertinent communication is a fundamental part of our project. In local practice this means that HGMCSs information must be disseminated also in forms, which illiterate community members can understand and make use of. However, our emphasis on co-designing the services means that every participant is involved even in the agile prototype design process, which requires learning communication within the highly heterogeneous co-design team.

After the survey of the existing IT networks the needed supplements are designed and established prior to the field experiments.

The local languages pose another interesting challenge. First of all, we need a sufficient number of interpreters (local language – English – local language), like local students, for CSH guided interviews and also to transcribe these interviews both in local language and in translated English. This is important for the reason that the correspondence between the answer in local language and its English translation is never one-to-one as the evolution of any language takes into account the local culture and habits, which are partly baked into the used expressions. These features are of importance in the context of epistemic assessments to extend our design space. The quest for common understanding is not limited to human languages, but will also cover more artificial languages, for the co-design team to control the technology.

One important item to be discussed at the first encountering meeting is the evaluation of our fitness-utility model and the project in terms of HGMCSs. This evaluation covers three aspects, namely the holistic, the metric and the epistemic evaluations. They all focus on the benefit, feasibility, validity, relevancy, and fitness of the model and the project.

The metric evaluation is based on variables with measurable quantities, like crop yield, cost of tilling, cost of fertilizers etc. With their values, we can determine the profit gained by the experiment parcel under consideration. The obtained profit numbers give one view on the considered evaluation qualities and especially on the benefits, which are of fundamental importance under conditions of poverty or nearby poverty. However, we need to keep in mind that the profit numbers alone give a limited scope of the synthesized view in the holistic context.

The epistemic evaluations of qualities like motive, truthlikeness, trust and willingness to participatory cooperation give us wider understanding to form the synthesized view on the sufficiency of the developed HGMCSs. Here we should keep ourselves to conclusions based on the primary projecting results as the dichotomized data is at least partly prone to subjective judgments and to possible biases associated with heuristics.

As pointed out by Gill and Hevner [8] in the context of a fitness-utility model the assessment of its fitness is a demanding task. Here we have at least three opportunities, by which we can have an influence on improved fitness of our model. The first option is the communication box of SDR. At least we could focus some of the publications in both categories to fitness related items so that the readers could become convinced of the benefits of our holistic model. The second option lies in the environment column of the DSR framework in various organizations of at least regional coverage. In the African context, we could proceed on this path up to the African Union. The third option is the needed landing of the recent global agreements and agendas [1-4] down to the grass-

root level as well as the associated need for synthesized views and messages. All in all, by doing our own job well we can let the publicity work for the fitness of our model.

4 Future Prospects of SDR

The impetus to innovate SDR was in our case the need to develop HGMCSs and to demonstrate the feasibility of our idea. Even if we still are in the midst of the task we are with our earlier experience already confident that we can reach sufficient outcomes. In addition, we can see that SDR itself is not bound to our particular application and can be explored in many other trans-disciplinary contexts.

Meinke [14] and most probably quite a few other scientists have presented the idea that during the present century it is time to emphasize the need of synthesizing approaches beside the earlier well established analytical research line. SDR can be seen as one response to this recent suggestion. The challenging part of SDR lies in the initial data of its design artifact EID. First the divide of the experiment population to not-learning and learning beings is by no means a straightforward task and needs careful considerations. Also, GTC sameness assumptions especially on the not-learning being group limits the step from the initial state to the final state. In many cases this limits the predictability, and the data for every prediction step has to be initialized. In addition, the theoretical feasibility of SDR framework remains to be analyzed. In our view SDR opens up to DSR the opportunity to become a major player on the synthesis research line.

Along our development of HGMCSs we hope that SDR can gain wider fitness and contribute significantly to the alleviation of poverty and hunger in developing countries. It should be recognized that SDR framework does not limit the possible climate service applications to the grass-root level. The reasons why we focused our attempts on the grass-root level in a developing country were our earlier experiences in this field, the expected feasibility of the attempt as a prototype project, and the urgent local need for help. However, the field is wide open for challenging undertakings and could lead to a snowball effect both in the fitness of SDR and an extended landing of pertinent global agreements and agendas [1-4]. We hope that SDR through our prototype experiment can convince the decision-makers to enhance the guidance of DSR also in climate-related issues.

5 Conclusions

With the SDR framework accomplished our progressing research has entered now the implementation of its prototype HGMCSs experiment in communities of an African developing country. By the outcomes we expect to demonstrate the feasibility, the validity and the relevancy of SDR as a fitness-utility model. We look forward to enhance its fitness with appropriate publications and contacts to relevant decision-makers.

We hope also that the outcomes of SDR prototype HGMCSs experiment encourage DSR community to seize on the need to develop tools suitable for designing trans-disciplinary interacting systems and to consider this as a challenging opportunity.

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